HIGHWAY-RAIL GRADE CROSSING PERSPECTIVE

A highway-rail grade crossing differs from a highway/highway intersection in that the train always has the right of way. From this perspective, the process for deciding what type of highway traffic control device is to be installed, or to even allow that a highway-rail grade crossing should exist is essentially a two-step process: 1) What information does the vehicle driver need to be able to cross safely? and, 2) Is the resulting driver response to a traffic control device "compatible" with the intended system operating characteristics of the highway and railroad facility?

MOTOR VEHICLE DRIVER NEEDS ON THE APPROACH

The first step involves three essential elements required for "safe" passage through the crossing, which are the same elements a driver needs for crossing a highway-highway intersection:

ADVANCE NOTICE - STOPPING SIGHT DISTANCE

The first element pertains to "stopping" or "braking" sight distance, which is the ability to see a train and/or the traffic control device at the crossing ahead sufficiently in advance so that a driver can bring the vehicle to a safe, controlled stop at least 4.5 m (15 ft) short of the near rail, if necessary. This applies to either a passive or active controlled crossing. Stopping sight distance is measured along the roadway and is a function of the distance required for the "design" vehicle, traveling at the posted speed limit to safely stop[1]. Insufficient stopping sight distance is often due to poor roadway geometry and/or surrounding topography.

TRAFFIC CONTROL DEVICE COMPREHENSION

The second element is a function of the type of traffic control device at the highway-rail crossing. There are typically three types of control devices, each requiring a distinct compliance response per the Uniform Vehicle Code2, various Model Traffic Ordinances and State regulations.

1. A crossbuck is a type of YIELD sign: the driver should be prepared to stop at least 4.5 m (15 ft) before the near rail if necessary, unless and until the driver can make a reasonable decision that there are no trains in hazardous proximity to the crossing, and it is safe to cross.

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[1] *A Policy on Geometric Design of Highways and Streets*. American Association of State Highway Transportation Officials (AASHTO). 2001 Edition. P. 449, available at www.ite.org, or 202-289-0222 and www.aashto.org

2 Uniform Vehicle Code is available at the following URL： http://mutcd.fhwa.dot.gov/

2. Operating flashing lights have the same function as a STOP sign: a vehicle is required to stop completely at least 4.5 m (15 ft) short of the near rail. Then, even though the flashing lights may still be operating, the driver is allowed to proceed after stopping (subject to State or local laws), when safe to do so.

3. Flashing lights with lowered gates are equivalent to a red vehicular traffic signal indication: a vehicle is required to stop short of the gate and remain stopped until the gates go up.

Motorist comprehension and compliance with each of these devices is mainly a function of education and enforcement. The traffic engineer should make full use of the various traffic control devices as prescribed in the MUTCD to convey a clear, concise and easily understood message to the driver, which should facilitate education and enforcement.

DECIDING TO PROCEED

The third element concerns the driver's decision to safely proceed through the grade crossing. It involves sight distance available both on the approach and at the crossing itself.

Approach (Corner) Sight Distance

On the approach to the crossing with no train activated traffic control devices (or STOP sign) present, in order to proceed at the posted speed limit, a driver would need to be able to see an approaching train, from either the left or right, in sufficient time to stop safely 4.5 m (15 ft) before the near rail. This would require an unobstructed field of vision along the approach sight triangle, the extent of which is dependent upon train and vehicle speed. These sight distances are available in the RHGCH. However, view obstructions often exist within the sight triangle, typically caused by structures, topography, crops or other vegetation (continually or seasonal), movable objects or weather (fog, snow, etc.). Where lesser sight distances exist, the motorist should reduce speed and be prepared to stop not less than 4.5 m (15 ft) before the near rail unless and until they are able to determine, based upon the available sight distance, that there is no train approaching and it is safe to proceed. Wherever possible, sight line deficiencies should be improved by removing structures or vegetation within the affected area, regrading an embankment, or realigning the highway approach.

Many conditions however cannot be corrected because the obstruction is on private property, or it is economically infeasible to correct the sight line deficiency. If available corner sight distance is less than what is required for the legal speed limit on the highway approach, supplemental traffic control devices such as enhanced advance warning signs, STOP or YIELD signs, or reduced speed limits (advisory or regulatory) should be evaluated. If it is desirable from traffic mobility criteria to allow vehicles to travel at the legal speed limit on the highway approach, active control devices should be considered.

Clearing Sight Distance

At all crossings, except those with gates, a driver stopped 4.5 m (15 ft) short of the near rail must be able to see far enough down the track, in both directions, to determine if sufficient time exists for moving their vehicle safely across the tracks to a point 4.5 m (15 ft) past the far rail, prior to the arrival of a train. Required clearing sight distance along both directions of the track, from the stopped position of the vehicle, is dependent upon the maximum train speed and the acceleration characteristics of the "design" vehicle.

At multiple track highway-rail grade crossings of two or more in-service railroad tracks through the roadway, and where two or more trains can operate simultaneously over or in close proximity to the crossing, the presence of a train on one track can restrict or obscure a driver's view of a second train approaching on an adjacent track. Such crossings must be treated the same as any other crossing having insufficient clearing sight distance. Even where there is only one track through the crossing, but additional tracks (such as a siding) are located adjacent to, but terminate before reaching the crossing, the sight distance to the limit of where railroad cars or equipment could be stored should be evaluated. Figure 1 is a diagram designed to illustrate some unusual conditions that would merit special consideration at a single-track highway-rail grade crossing.

Figure 1

This figure shows an aerial view of a highway-rail grade crossing. A single-rail track stretches across the width of the figure. A locomotive is located on both the right and left-ends of the track. There is a second track on right side of the crossing with a locomotive on it. This track ends before the roadway. An automobile is stopped behind a "stop line" in the middle of the figure. On both sides of the intersection there is a symbol for a flashing light signal. In the lower left quadrant, a building is shown that restricts sight the sight of a locomotive approaching from the left. There is a 45-degree line between the automobile and the locomotive on the left end of the track that demonstrates the obstructed clearing sight distance caused by the building. Another 45-degree line stretches from the automobile to the locomotive on the right end of the track that demonstrates the obstructed clearing sight distance caused by the locomotive on the second track. There is a box between the automobile and locomotive that says, "D is the minimum unobstructed viewing distance to determine if the crossing should be considered for upgrade to automatic gate control."

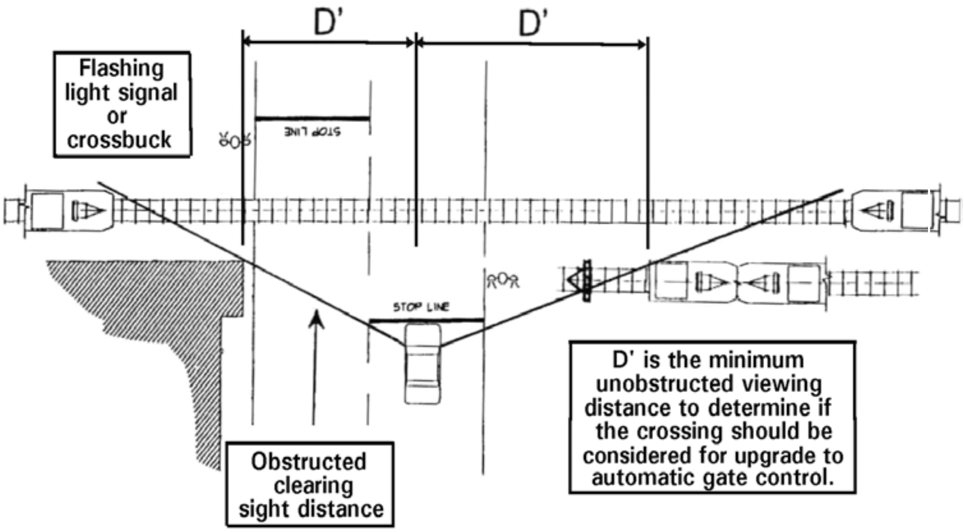


FIGURE 1

Table 2, prepared by members of the TWG, relates the typical minimal clearing sight distances for various train speeds and vehicle types. (It should be noted the column for 65 foot double trucks generally corresponds to the distances listed in table 36 on page 133 of the *RHGCH*, under the column for vehicle speed of "0 MPH." Vehicle acceleration data has been interpreted from the *Traffic Engineering Handbook*.[3]) The person or agency evaluating the crossing should determine the specific design vehicle, pedestrian, bicyclist, or other non-motorized conveyance and compute clearing sight distance if it is not represented in the table. Also note the table values are for a level, 90-degree crossing of a single track. If other circumstances are encountered, the values must be re-computed.

TABLE 2
CLEARING SIGHT DISTANCE (in feet) *

Train	Car	Single Unit-Truck	Bus	WB-50 Semi-Truck	65-ft Double Truck	Pedestrian
10	105	185	200	225	240	180
20	205	365	400	450	485	355
25	255	455	500	560	605	440
30	310	550	600	675	725	530
40	410	730	795	895	965	705
50	515	910	995	1120	1205	880
60	615	1095	1195	1345	1445	1060
70	715	1275	1395	1570	1680	1235
80	820	1460	1590	1790	1925	1410
90	920	1640	1790	2015	2165	1585

* A single track, 90-degree, level crossing.

** walking 1.1 mps (3.5 fps) across 2 sets of tracks feet apart, with a two second reaction time to reach a decision point 3 m (10 ft) before the

[3] *Traffic Engineering Handbook - Fourth Edition*. Institute of Transportation Engineers. Washington D.C.: 1990. available at www.ite.org, or 202-289-0222

center of the first track, and clearing 3 m (10 ft) beyond the center line of the second track. Two tracks may be more common in commuter station areas where pedestrians are found. (See Figure 2).

Note: 1 meter = 0.3048 feet.

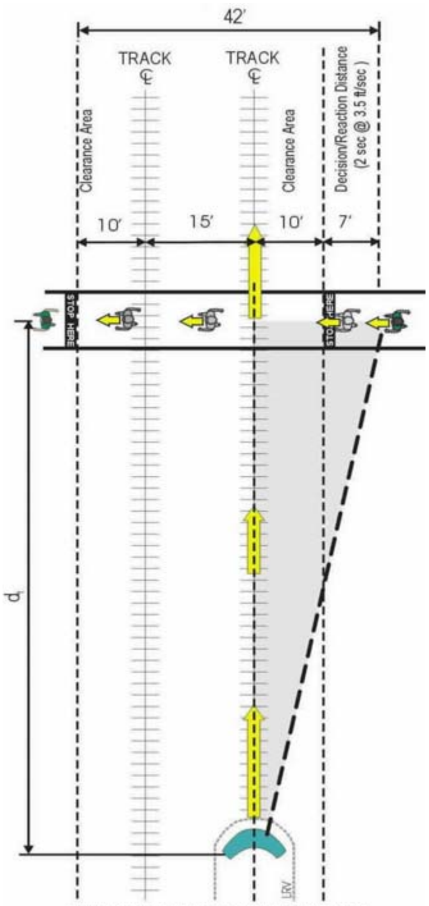
<u>Figure 2</u>: Pedestrian Sight Triangle

A highway-rail grade crossing is displayed depicting a pattern for the pedestrian sight triangle. The distance the pedestrian travels from one side of the crossing to the other is 42 feet. There are two tracks in the crossing. The distance is broken up into the following respective categories:

– 7 ft. Decision/Reaction Distance of 2 seconds @3.5 feet per second;
– 10 ft. Clearance Area just before a rail track;
– 15 ft. between two rail tracks;
– 10 ft. from last rail track to clearance area.

A locomotive is approaching from the south in the diagram. The pedestrian is on the immediate right of the crossing starting at the Decision/Reaction Distance category-space. The figure of the pedestrian is shown several times to represent the movement over the crossing. There is a “STOP HERE” label on both sides of the crossing immediately prior to the beginning of the clearance area. There is a dotted line reaching from the pedestrian’s figure to the first track that demonstrates the sight distance to an approaching locomotive. The area inside the triangle is shaded. The sight triangle demonstrates that the pedestrian is 17 ft. from the center of the first track.

If there is insufficient clearing sight distance, and the driver is unable to make a safe determination to proceed, the clearing sight distance needs to be improved to safe conditions, or flashing light signals with gates, or closure, or grade separation should be considered. (See Recommendation, “3.F.3”.)



PEDESTRIAN SIGHT TRIANGLE
FIGURE 2

SYSTEMS OPERATING REQUIREMENTS AND OBJECTIVES

The second step involves a traffic control device selection process considering respective highway and rail system operational requirements. From a highway perspective, concerns for roadway capacity and drivers= expectations may mandate the type of traffic control present. There are circumstances when train interference can be so disruptive to highway operations that a highway-rail grade crossing is incompatible with system objectives. From the rail perspective, there can also be circumstances when the potential for highway traffic interference can be sufficiently disruptive, or potentially so catastrophic, that closure, grade separation, or activated control would be considered. It is within these contexts where operation and safety variables should be considered, such as:

a) Highway - AADT (Annual Average Daily Traffic), legal and/or operating speed;

b) Railroad - train frequency, speed and type (passenger, freight, other);
c) Highway - Functional classification and/or design level of service;
d) Railroad - FRA Class of Track and/or High Speed Rail corridors;
e) Proximity to other intersections;
f) Proximity to schools, industrial plants and commercial areas;
g) Proximity to rail yards, terminals, passing tracks and switching operations;
h) Available clearing and corner sight distance;
i) Prior accident history and predicted accident frequency;
j) Proximity and availability of alternate routes and/or crossings; and
k) Other geometric conditions.

Special consideration should also be given to situations where highway-rail crossings are sufficiently close to other highway intersections that traffic waiting to clear the adjacent highway intersection can queue on or across the tracks. Additionally, special consideration is required when there are two or more sets of tracks sufficiently close to each other that traffic stopped on one set could result in a queue of traffic across the other.

HIGHWAY SYSTEM OBJECTIVES

Roads and streets which are planned, designed, constructed, maintained and operated by public agencies serve two important but conflicting functions: land access and mobility. Overriding these interests should be a concern for safety.

An example of a facility constructed primarily for mobility is the Interstate highway. Access is only by interchanges, with ramps and acceleration/deceleration lanes. These allow vehicles to enter and leave the highway with minimal effect on the through traffic stream. Interstate highways do not have direct driveway access to adjacent properties, grade level intersections, transit stops, pedestrian and bicycle facilities or highway-rail grade crossings, all of which interfere with the free flow of traffic.

A local street is at the other end of the spectrum. It provides direct access to adjacent land, with driveways to parking facilities and provision of services such as on-street deliveries and trash pickup. The

low-type design of local streets, including presence of parked vehicles, pedestrians and bicycles, makes travel at any significant speed undesirable.

Many roads and highways fall in the spectrum between Interstate highways and local roads, and fulfill their purpose with varying degrees of success. Mobility is affected by providing adequate access to adjacent development in an environment complicated by driveways and street intersections, and other modes of transportation such as transit, bicycles, pedestrians and railroads. The concept is illustrated in Figure 3.[4]

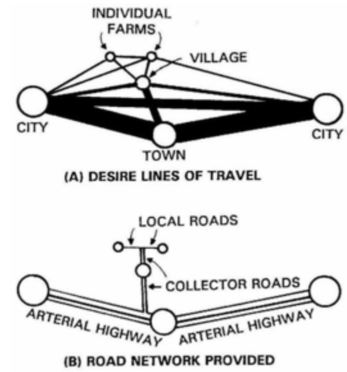


FIGURE 3

Figure 3:

A) Desired Lines of Travel

The figure depicts the desired lines of travel between several points and is depicted in the form of an irregular pentagon. A circle, representing "City", "Town", and "City", respectively is shown on each of the three southern points of the figure. On the left and right points of the irregular pentagon, there is a label that reads "City." The far-south point of the pentagon reads "Town." In the center of the pentagon there is a circle with an arrow pointing to it labeled "Village." Above "Village" are two smaller circles that are labeled "Individual Farms". Twelve lines connect the various circles of the pentagon indicating the desired lines of travel between the various points. There are thick black lines leading from each "City" to the "Town".

B) Road Network Provided

The figure shows the same pattern of circles as Figure A that are labeled the same as in A). There are five lines connecting the points indicating the roadway network. "Arterial Highway" is written for the segments connecting both "City" circles to the "Town". To the left of the "Town" is a vertical line labeled "Collector Roads" which runs to the "Village" circle and extends slightly beyond the village. Horizontally placed atop the "Collector Roads" is a small "local roads" line with the two "Individual Farms" circles on each endpoint. Each line represents travel between the various points.

A highway-rail grade crossing can impede highway traffic flow based on several factors. The most obvious is, of course, blockages by trains. The geometry of the crossing and approaches, and the condition of the surface can present additional impediments.

LEVELS OF SERVICE

4 *A Policy on Geometric Design of Highways and Streets*. American Association of State Highway Transportation Officials (AASHTO). 2001 Edition. pages 4 and 5, available at www.ite.org, or 202-289-0222 and www.aashto.org.

The performance of a road or street is normally described in terms of "Level of Service.[5]" The Level of Service is a concept that describes the operational characteristics of the traffic stream and how they are perceived by drivers and passengers. Speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience are factors that characterize levels of service. Traffic flow characteristics are described by letter designations; "A" the best, corresponding to a free flow condition, and "F" the worst, corresponding to a breakdown of flow or "stop and go" condition. Table 3 provides guidance for selecting Level of Service for particular locations.

TABLE 3
GUIDE FOR SELECTION OF DESIGN LEVELS OF SERVICE

	Type of Area and Appropriate Level of Service			
Highway	**Rural**	**Rural**	**Rural**	**Urban and**
Freeway	B	B	C	C
Arterial	B	B	C	C
Collector	C	C	D	D
Local	D	D	D	D

Note: General operating conditions for levels of service:

A - free flow, with low volumes and high speeds.

B - reasonably free flow, but speeds beginning to be restricted by traffic conditions.

C - in a stable flow zone, but most drivers restricted in freedom to select their own speed.

D - approaching unstable flow, drivers have little freedom to maneuver.

E - unstable flow, may be short stoppages.

F - forced flow, congested stop-and-go operation.

(Source: A Policy on Geometric Design of Highways and Streets. AASHTO. 2001. Page 90)

The nominal level of service normally considered acceptable during the planning and design of a new or reconstructed roadway is "C" which is within the range of stable flow. The presence of a highway-rail grade crossing can drop the level of service below "C".

SAFE APPROACH SPEED

Passive crossings with a restricted sight distance require an engineering study to determine the safe approach speed based upon available stopping and/or corner sight distance. As a minimum, an advisory speed posting may be appropriate, or a reduced regulatory speed limit might be warranted (if it can be effectively enforced). (See Guidance Section of this Report, "3.F.2c.") Active devices improve highway capacity and level of service in the vicinity of a

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5 *Highway Capacity Manual, Special Report 209, 3rd Edition*. Transportation Research Board. Washington, D.C.: 1994, available at www.ite.org or 202-289-0222 or www.trb.org.

crossing, particularly where corner sight distances are restricted. When flashing lights are active however, a driver is required to stop and look for a train.

The effects of such delay increases as volume increase. Queues become longer and vehicle delay increases proportionally. These delays are observed by the driver as a reduction in the facility=s level of service. The type of control installed at highway-rail crossings needs to be evaluated in the context of the highway system classification and level of service.

RAILROAD SYSTEMS - FUNCTIONAL CLASSIFICATION

A commonly used means of classifying freight and "heavy rail" passenger rail routes is by their respective FRA designations for class of track. This Federal designation establishes the maximum authorized speed for freight and passenger trains, and places requirements on the track maintenance criteria, vehicle standards, and train control signal systems. In some respects, the FRA Class of Track may be viewed as a surrogate for rail traffic volume. In general, railroads are not likely to make the additional investment required to maintain tracks to a higher standard absent sufficient traffic volume to justify the added expense. Table 4 indicates maximum permissible train speeds for various classes of track.

TABLE 4

MAXIMUM TRAIN SPEEDS BY CLASS OF TRACK *

Class of Track	**Freight**	**Passenger**
Class 1	10 MPH	15 MPH
Class 2	25 MPH	30 MPH
Class 3	40 MPH	60 MPH
Class 4	60 MPH	80 MPH
Class 5	80 MPH	90 MPH
Class 6	110 MPH	110 MPH
Class 7	125 MPH	125 MPH
Class 8	160 MPH	160 MPH
Class 9	200 MPH	200 MPH

* If train operations exceed 177 km/h (110 mph) for a track segment that will include highway-rail grade crossings, FRA=s approval of a complete description of the proposed warning/barrier system to address the protection of highway traffic and high speed trains must be obtained in advance. All elements of the warning/barrier system must be functioning.
Source: 49 CFR 213
Note: 1 mph = 1.61 km/h

Not unlike the system specification that all highway-rail crossings on full control access highways be grade separated, it is only logical that certain rail systems should have similar status. In 1994, the FRA defined a core railroad system of approximately 128,800 km (80,000 mi) known as the Principal Railroad Lines (PRLs). These lines have one or more of the following attributes: Amtrak service; defense essential; or, annual freight volume exceeding 20 million gross tons. This core network was described in the Department of Transportation's 1994 Action Plan to improve highway-rail grade crossing safety. The Action Plan set forth a long-term goal of eliminating (grade separating or realigning) intersections of PRLs and highway routes on the National Highway System (NHS - defined as "an interconnected system of principal arterial routes to serve major population centers, intermodal transportation facilities and other major travel destinations; meet national defense requirements; and serve interstate and interregional travel").

FUNCTION, GEOMETRIC DESIGN AND TRAFFIC CONTROL

Functional classification is important to both the highway agency and railroad operator. Even though geometric criteria can be determined without reference to the functional classification, the designer should consider the function that the highway is expected to serve. The functional classification of the highway defines the geometric criteria to be used in its planning, design and construction. Where the highway intersects a railroad, the crossing, whether grade separated or at-grade, should be designed consistently with the functional classification of the highway or street. These design considerations can also extend to traffic control.

Drivers form expectancies based on their training and experience; that is, situations which occur in similar environments and in similar ways are incorporated into the driver=s knowledge base, along with successful responses to the situations. Drivers on a US or state-numbered route, or on a facility having a higher functional classification, have higher expectancies for operating characteristics, level of service and traffic control than do those same drivers on local roads and streets. These higher classed roads and streets also tend to serve a more diverse cross-section of vehicles and lading, including transit buses, intercity buses and haz-mat carriers. For these reasons, functional classification of the road or street should be considered in the decision-making process concerning geometric design and traffic control devices.